CLAIMS

1. An echo processing device for attenuating echo components of a direct signal X1n in a return signal Y2n, said device comprising:
   - means for calculating a receive gain Gr_n and a send gain Ge_n;
   - first gain application means for applying the receive gain Gr_n to the direct signal and producing an input signal X2n emitted into an echo generator system; and
   - second gain application means for applying the send gain Ge_n to an output signal Y1n from the echo generator system and producing the return signal Y2n;

   said device further comprising means for calculating a coupling variable COR characteristic of the acoustic coupling between the direct signal X1n or the input signal X2n and the output signal Y1n, said gain calculation means being adapted to calculate the receive gain Gr_n and the send gain Ge_n on the basis of said coupling variable.

2. An echo processing device according to claim 1, comprising means for estimating the instantaneous power of the direct signal X1n or the input signal X2n and the instantaneous power of the output signal Y1n, said gain calculation means being adapted to calculate the receive gain Gr_n and the send gain Ge_n on the basis of a variable G determined as a function of the estimated power of the direct signal or the input signal and the estimated power of the output signal, and as a function of the coupling variable COR, in accordance with the following equation:

$$G = \frac{P2n}{P2n + COR \cdot P1n}$$

where P1n and P2n are respectively an estimate at the

time concerned of the power of the direct signal X1n or the input signal X2n and the power of the output signal Y1n.

3. An echo processing device according to claim 2, in which the gain calculation means determine the receive gain Gr_n and the send gain Ge_n recursively from the following equations:

$$Ge_n = \gamma \cdot Ge_{n-1} + (1-\gamma) \cdot G$$

$$Gr_n = 1 - \delta \cdot Ge_n$$

where Ge_{n-1} is the send gain at the preceding calculation time and γ and δ are positive constants less than 1.

4. An echo processing device according to any one of claims 1 to 3, in which the coupling variable COR is obtained by calculating the correlation between the direct signal X1n or the input signal X2n and the output signal Y1n.

5. An echo processing device according to claim 4, in which the calculation of the correlation between the direct signal X1n or the input signal X2n and the output signal Y1n is an envelope correlation calculation.

6. An echo processing device according to claim 5, in which, in said envelope correlation calculation, the coupling variable COR is a function of the maximum value Maxcor of the values corr(j) of the correlation between the direct signal X1n or the input signal X2n and the output signal Y1n, said correlation values corr(j) being calculated over a time window considered, and each being obtained from the equation:

$$corr(j) = \frac{\sum_{i=0}^{LM-1} P1(i) \cdot P2(i+j)}{\sum_{i=0}^{LM-1} P1^2(i)}$$

in which i is a sampling time in the calculation time window of duration LM, j is a shift value between the input signal X2n and the output signal Y1n, and P1(t) and P2(t) are respectively an estimate of the power of the direct signal X1n or the input signal X2n and an estimate of the power of the output signal Y1n at a time t.

7. An echo processing device according to claim 6, in which the coupling variable COR is linked to the maximum value Maxcor of the correlation values corr(j) calculated over a calculation time window considered from the equation:

$$COR = Exp(k.Maxcor)$$

in which Exp is the exponential function and k is a positive constant.

8. An echo processing device according to any preceding claim, in which the input signal X2n is emitted into the echo generator system by at least one loudspeaker and the output signal Y1n is obtained from the echo generator system by at least one microphone.

9. An echo processing device according to any one of claims 1 to 8, further comprising an echo canceller receiving at its input said input signal X2n emitted into the echo generator system and the signal Y3n from the echo generator system, the echo canceller comprising a finite impulse response identification

filter whose response is representative of the response of the echo generator system, and the identification filter being adapted to generate a filtering signal Sn and comprising means for subtracting the filtering signal Sn from the signal Y3n to produce an output signal Y1n that is received at the input of said send gain application means.

10. An echo canceller for attenuating in an output signal Y1n echo components of an input signal X2n emitted into an echo generator system, said device comprising:

- a finite impulse response identification filter whose response is representative of the response of the echo generator system, receiving the input signal X2n at its input and generating a filtering signal Sn;
- subtraction means receiving at an input a signal Y3n from the echo generator system, at least one component of which is a response of the echo generator system to the input signal X2n, and the filtering signal Sn, and adapted to subtract the filtering signal Sn from the signal Y3n and to produce the output signal Y1n;
- means for adapting the coefficients of the identification filter as a function of an adaptation step μ_n; and
- means for calculating the adaptation step μ_n, said adaptation step calculation means comprising means for estimating the power P1n of the input signal X2n and the power P3n of the signal Y3n and means for calculating a first coupling variable COR2 characteristic of the acoustic coupling between the input signal X2n and the signal Y3n from the echo generator system, the adaptation step μ_n of the identification filter being calculated as a function of the estimated powers P1n, P3n and as a function of the first coupling variable COR2.

11. A device according to claim 10, in which the adaptation step μ_n is obtained from the equation:

$$\mu_n = \frac{P1n}{\alpha \cdot P1n + COR2.P3n}$$

in which α is a positive constant and P1n and P3n are respectively an estimate of the power of the input signal X2n and an estimate of the power of the signal Y3n from the echo generator system at the time concerned.

12. A device according to claim 10 or claim 11, in which the first coupling variable COR2 is obtained by calculating the correlation between the input signal X2n and the signal Y3n.

13. A device according to claim 12, in which the calculation of the correlation between the input signal X2n and the signal Y3n is an envelope correlation calculation.

14. A device according to claim 13, in which the first coupling variable COR2 is a function of the maximum value Maxcor2 of correlation values corr2(j) calculated over a time window considered, each of the correlation values corr2(j) being calculated from the following equation:

$$corr2(j) = \frac{\sum_{i=0}^{LM-1} P1(i) \cdot P3(i+j)}{\sum_{i=0}^{LM-1} P1^2(i)}$$

in which:

i is a sampling time in the calculation time window of duration LM and j is a shift value between the input signal X2n and the signal Y3n; and

P1(t) and P3(t) are respectively an estimate of the power of the input signal X2n and an estimate of the power of the signal Y3n at the time t concerned.

15. A device according to claim 14, in which the first coupling variable COR2 is linked to the maximum value Maxcor2 of said correlation values corr2(j) by the following equation, in which k is a positive constant:

$$COR2 = \frac{k}{Maxcor2}$$

16. An echo canceller according to any one of claims 10 to 15, in which the adaptation step calculation means further comprise means for calculating a second coupling variable COR characteristic of the acoustic coupling between the input signal X2n from the echo generator system and the output signal Y1n, the second coupling variable COR being obtained by calculating the correlation between the input signal X2n and the output signal Y1n, and the adaptation step μ_n of the identification filter being calculated as a function of the second coupling variable COR.

17. An echo canceller according to claim 16, in which the second coupling variable COR is obtained from an envelope correlation calculation between the input signal X2n and the output signal Y1n.

18. An echo canceller according to claim 17, in which the second coupling variable COR is a function of the maximum value Maxcor of the values corr(j) of the

correlation between the input signal X2n and the output signal Y1n, said correlation values corr(j) being calculated over a time window considered and each of them being obtained from the equation:

$$corr(j) = \frac{\sum_{i=0}^{LM-1} P1(i) \cdot P2(i+j)}{\sum_{i=0}^{LM-1} P1^2(i)}$$

in which i is a sampling time in the calculation window of duration LM, j is a value of a shift value between the input signal X2n and the output signal Y1n, and P1(t) and P2(t) are respectively an estimate of the power of the input signal X2n and an estimate of the power of the output signal Y1n at a time t.

19. An echo canceller according to any one of claims 16 to 18, characterized in that the adaptation step μ_n is calculated from the equation:

$$\mu_n = \frac{COR}{COR2} \cdot \frac{P1n}{\alpha . P1n + COR2 \cdot P3n}$$

in which α is a positive constant and P1n and P3n are respectively an estimate of the power of the input signal X2n and an estimate of the power of the signal Y3n from the echo generator system at the time concerned.

20. An echo processing device according to claim 9, in which the echo canceller is according to any one of claims 10 to 15, the adaptation step μ_n of the identification filter being calculated as a function of the estimated power P1n of the direct signal X1n or the input signal X2n, the estimated power P3n of the signal Y3n from the echo generator system, and said

coupling variable COR2.

21. An echo processing device according to claim 9, in which the echo canceller is according to any one of claims 16 to 19, the adaptation step μ_n of the identification filter being calculated as a function of the estimated power P1n of the direct signal X1n or the input signal X2n, the estimated power P3n of the signal Y3n from the echo generator system, and said coupling variable COR, COR2.

22. An echo processing device for a multichannel communications system comprising N receive channels, N being an integer greater than or equal to 2, and M send channels, M being an integer greater than or equal to 1, each of the N receive channels i comprising an output transducer (LSi) that produces a sound pressure wave in response to an input signal X2n(i) derived from a direct signal X1n(i), each of the M send channels j comprising an input transducer (MCj) that converts a sound pressure wave into an output signal Y1n(j), said echo processing device being adapted to attenuate in each output signal Y1n(j) echo components stemming from some or all of the N input signals X2n(i) and resulting from the acoustic coupling between the input transducer of the send channel concerned and some or all of the M output transducers, said device being characterized in that it comprises:
- means for calculating receive gains $Gr_n(i)$ and send gains $Ge_n(j)$;
- means for applying receive gains $Gr_n(i)$ to each direct signal X1n(i) and producing the corresponding input signal X2n(i):
- means for applying send gains $Ge_n(j)$ to each output

signal Y1n(j) and producing the corresponding return signal Y2n(j); and

- means for calculating, for each send channel j, N coupling variables COR(j,i), for i varying from 1 to N, each of which being characteristic of the acoustic coupling between the output signal Y1n(j) of the send channel and one of the N input signals X2n(i);

said gain calculation means being adapted to calculate each receive gain $Gr_n(i)$ and each send gain $Ge_n(j)$ on the basis of the N coupling variables COR(j,i) calculated for the associated send channel j.

23. A device according to claim 22, comprising means for estimating the instantaneous power $P1n_i$ of each input signal X2n(i) and the instantaneous power $P2n_j$ of each output signal Y1n(j), said send gain calculation means being adapted to calculate each send gain $Ge_n(j)$ on the basis of N variables G(j,i), for i varying from 1 to N, each of which is determined as a function of the estimated power of an input signal X2n(i) and the estimated power of the output signal Y1n(j) of the send channel concerned and as a function of the corresponding coupling variable COR(j,i), each of the variables G(j,i) being obtained from the following equation:

$$G(j,i) = \frac{P2n_j}{P2n_j + COR(j,i) \cdot P1n_i}$$

in which $P1n_i$ and $P2n_j$ are respectively an estimate of the power of the input signal X2n(i) concerned and an estimate of the power of the output signal Y1n(j) concerned at the time concerned.

24. A device according to claim 23, in which each send gain $Ge_n(j)$ is determined from the minimum value of the

N variables G(j,i), for i varying from 1 to N, calculated for the associated send channel j.

25. A device according to claim 24, in which each send gain $Ge_n(j)$ is determined from the equation:

$$Ge_n(j) = \gamma \cdot Ge_{n-1}(j) + (1-\gamma) \cdot \min_i(G(j,i))$$

in which $Ge_{n-1}(j)$ is the send gain of the send channel j at the time of the preceding calculation, γ is a positive constant less than 1, and $\min_i(G(j,i))$ is the minimum value of the N variables G(j,i) for i varying from 1 to N.

26. A device according to claim 25, in which all the receive gains $Gr_n(i)$ have the same value, which is determined from the equation:

$$Gr_n(i) = 1 - \delta \cdot \max_j(Ge_n(j))$$

in which δ is a positive constant less than 1 and $\max_j(Ge_n(j))$ is the maximum value of the M send gains $Ge_n(j)$, for j varying from 1 to M.

27. A device according to any one of claims 22 to 25, in which each of said receive gains $Gr_n(i)$ is equal to 1.

28. A device according to any one of claims 22 to 27, in which each coupling variable COR(j,i) is obtained by calculating the correlation between the corresponding output signal Y1n(j) and the corresponding input signal X2n(i).

29. A device according to claim 28, in which the calculation of the correlation between an output signal Y1n(j) and an input signal X2n(i) is an envelope correlation calculation.

30. A device according to claim 29, in which, in said envelope correlation calculation, each coupling variable COR(j,i) is a function of the maximum value Maxcor of the values $corr_{ji}(d)$ of the correlation between the output signal Y1n(j) and the input signal X2n(i), said correlation values $corr_{ji}(d)$ being calculated over a predefined time window and each obtained from the equation:

$$corr_{ji}(d) = \frac{\sum_{c=0}^{LM-1} P1n_i(c) \cdot P2n_j(c+d)}{\sum_{c=0}^{LM-1} P1n_i{}^2(c)}$$

in which c is a sampling time in the calculation time window of duration LM, d is a shift value between the input signal X2n(i) and the output signal Y1n(j), and $P1n_i(t)$ and $P2n_j(t)$ are respectively an estimate of the power of the input signal X2n(i) and an estimate of the power of the output signal Y1n(j) at a time t.

31. An echo canceller for a multichannel communications system comprising N receive channels, N being an integer greater than or equal to 2, and M send channels, M being an integer greater than or equal to 1, each of the N receive channels i comprising an output transducer (LSi) that produces a sound pressure wave in response to an input signal X2n(i), and each of the M send channels j comprising an input transducer (MCj) that converts a sound pressure wave into an output signal Y1n(j), the echo canceller comprising:

- for each send channel j, N identification filters Fij with variable coefficients for estimating the acoustic coupling between each of the N output

transducers (LSi) and the input transducer (MCj) of the send channel j, and

- for each filter Fij, means for adapting the coefficients of the filter as a function of an adaptation step $\mu_n(i,j)$ and means for calculating the adaptation step $\mu_n(i,j)$,

- means for estimating the instantaneous power $P1n_i$ of each input signal X2n(i) and the instantaneous power P2nj of each output signal Y1n(j), and

- means for calculating, for each send channel j, N coupling variables COR(j,i), for i varying from 1 to N, each of which being characteristic of the acoustic coupling between the output signal Y1n(j) of the send channel j and one of the N input signals X2n(i),

the means for calculating the adaptation step $\mu_n(i,j)$ for a filter Fij associated with a receive channel i and a send channel j being adapted to calculate the adaptation step $\mu_n(i,j)$ as a function of the powers $P1n_i$, for i varying from 1 to N, estimated for the N receive channels, as a function of the estimated power P2nj of the send channel j, and as a function of the N coupling variables COR(j,i), for i varying from 1 to N, associated with the send channel j.

32. A device according to claim 31, in which an adaptation step $\mu_n(i,j)$ for a filter Fij associated with a receive channel i and a send channel j is obtained from the following equation, in which b_i is a positive constant:

$$\mu_n(i,j) = \frac{P1n_i}{b_i \cdot P1n_i + COR(j,i) \cdot P2n_j + \sum_{k \neq i} COR(j,k) \cdot P1n_k}$$

33. A device according to claim 31 or claim 32, in which a coupling variable COR(j,i) is obtained by calculating the correlation between the output signal Y1n(j) and

the input signal X2n(i).

34. A device according to claim 33, in which the calculation of the correlation between the output signal Y1n(j) and the input signal X2n(i) is an envelope correlation calculation.

35. A device according to claim 34, in which the coupling variable COR(j,i) is a function of the maximum value Maxcor(j,i) of the correlation values $corr_{ji}(d)$, calculated over a time window considered, each of the correlation values $corr_{ji}(d)$ being calculated from the equation:

$$corr_{ji}(d) = \frac{\sum_{c=0}^{LM-1} P1n_i(c) \cdot P2n_j(c+d)}{\sum_{c=0}^{LM-1} P1n_i^2(c)}$$

in which <u>c</u> is a sampling time in the calculation time window of duration LM, <u>d</u> is an offset between the input signal X2n(i) and the output signal Y1n(j), and $P1n_i(t)$ and $P2n_j(t)$ are respectively an estimate of the power of the input signal X2n(i) and an estimate of the power of the output signal Y1n(j) at a time <u>t</u>.

36. A device according to claim 35, in which the coupling variable COR(j,i) is linked to the maximum value Maxcor(j,i) of said correlation values $corr_{ji}(d)$ by the following equation, in which <u>k</u> is a positive constant:

$$COR(j,i) = \frac{k}{Maxcor(j,i)}$$

37. A device according to any one of claims 31 to 36, in which each filter Fij associated with a receive

channel i and a send channel j generates a filtering signal that is subtracted from the output signal Y1n(j) to provide a filtered signal Y2n(j), said device further comprising means for calculating, for each send channel j, N second coupling variables COR2(j,i), for i varying from 1 to N, each of which being characteristic of the acoustic coupling between the filtered signal Y2n(j) from the send channel and one of the N input signals X2n(i), the adaptation step μ_n(i,j) of an identification filter Fij associated with a receive channel i and a send channel j being calculated as a function of said N second coupling variables COR2(j,i).

38. A device according to claim 37, in which an adaptation step μ_n(i,j) for a filter Fij associated with a receive channel i and a send channel j is obtained from the following equation, in which b_i is a positive constant:

$$\mu_n(i,j) = \frac{COR(j,i)}{COR2(j,i)} \cdot \frac{P1n_i}{b_i \cdot P1n_i + COR(j,i) \cdot P2n_j + \sum_{k \neq i} COR(j,k) \cdot P1n_k}$$

39. A device according to claim 37 or 38, further comprising, for each pair comprising a receive channel i and a send channel j, gain application means for applying a receive gain Gr_n(i) to the input signal X2n(i) and a send gain Ge_n(j) to the filtered signal Y2n(j), said gains Gr_n(i), Ge_n(j) being calculated on the basis of the N second coupling variables COR2(j,i) determined for the send channel j.